Watershed Benefits of Environmental Monitoring Performed by a Medium-Sized City

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Abstract
Local government agencies perform environmental monitoring to fulfill requirements of permits and regulations. The City of Bremerton will describe the benefits of environmental monitoring for local watershed improvement projects.

Bremerton performs environmental monitoring for several programs including combined sewer overflows (CSOs), stormwater, drinking water, forestry operations and biosolids land application. Environmental monitoring data is used for both regulatory, baseline, and investigative purposes.

Bremerton collects a variety of data including: water quality chemistry of stormwater, CSOs, groundwater and local streams; flow data of streams and CSOs; water level data of production and monitoring groundwater wells; soil, groundwater and stream chemistry of biosolids applied forest lands; and water chemistry, temperature, and stream morphology for the drinking water surface supply program.

The program is diverse in that water quality data is collected from both urban and forested environments. Programs of interest to other medium-sized cities and counties will be featured: combined sewer overflows, detection of inappropriate connections to the stormwater system, stream morphology survey, and stream temperature survey.

Bremerton is able to provide local environmental data of high quality and is a participant in watershed studies and public education projects including: Puget Sound Naval Shipyard Environmental Investment (ENVVEST), 2514 Watershed Planning, Groundwater Guardians, Watersheds for Salmon, Water Purveyors Association of Kitsap Water Conservation Task Force and the Kitsap Stormwater Consortium.

Methods
The focus of this presentation is to demonstrate the benefits of an environmental monitoring program. The city uses standard methods for collecting environmental monitoring data. The city frequently partners with agencies to obtain expertise including King County Department of Natural Resources, Timber-Fish-Wildlife/Northwest Indian Fisheries Commission, Washington State Department of Ecology Environmental Investigations Laboratory Section, and the United States Geological Survey

Environmental monitoring projects have written Quality Assurance Project Plans; some plans require approval by the Department of Ecology or Department of Health prior to implementation. Other projects have a plan that could obtain approval if required. Additionally, regulatory and internal reports document status of projects.

Laboratory analyses are performed by state-accredited or certified laboratories, and field data are collected by experienced technicians.

Bremerton’s Combined Sewer Overflow Monitoring Program

About 60% of the City of Bremerton is combined sewers where both stormwater and wastewater are transported to the wastewater treatment plant in the same collection system. During heavy rains the system capacity is exceeded and the excess combined stormwater and sewage is discharged into the Port Washington Narrows or Sinclair Inlet. The city has an aggressive program to reduce to less than one overflow per year per outfall. Water quality monitoring of combined sewer overflows is performed according to a consent decree with the Puget Soundkeepers Alliance. The water quality monitoring program was initiated in 1996 and, to date 126 CSO discharge samples have been collected from 16 CSO sites. Samples are analyzed for nutrients, fecal coliforms, TSS, BOD, EPA Priority Pollutant metals and organics (Fohn 1995).

CSO water quality samples are obtained from drainage basins with varying land use characteristics. The water quality characteristics from basins with predominantly commercial/industrial land use and residential land use were compared statistically. The One-Way Analysis of Variance nonparametric Kruskall-Wallis test with a minimum of five observations was used. Analysis was performed for ammonia, total phosphorus, and total recoverable copper and zinc. Overflow sites 1, 4, 10 and 17 represent commercial/industrial land use and Overflow sites 6, 7, 8 and 9 represent residential land use.

The residential land use sites show similar water quality of combined sewer discharges, whereas the industrial land use sites do not show similar water quality (Table 1). This indicates that the residential basins have similar water quality. For monitoring purposes it is not necessary to sample each residential basin. However, the basins with industrial/commercial land use are not similar in water quality and each of these basins requires continued sampling to adequately characterize.

Table 1. Similarity of water quality of CSO sites.

	Residential	*Commercial/Industrial*
Ammonia	Yes	No
Total Phosphorus	Yes	No
Copper	Yes	No
Zinc	Yes	No

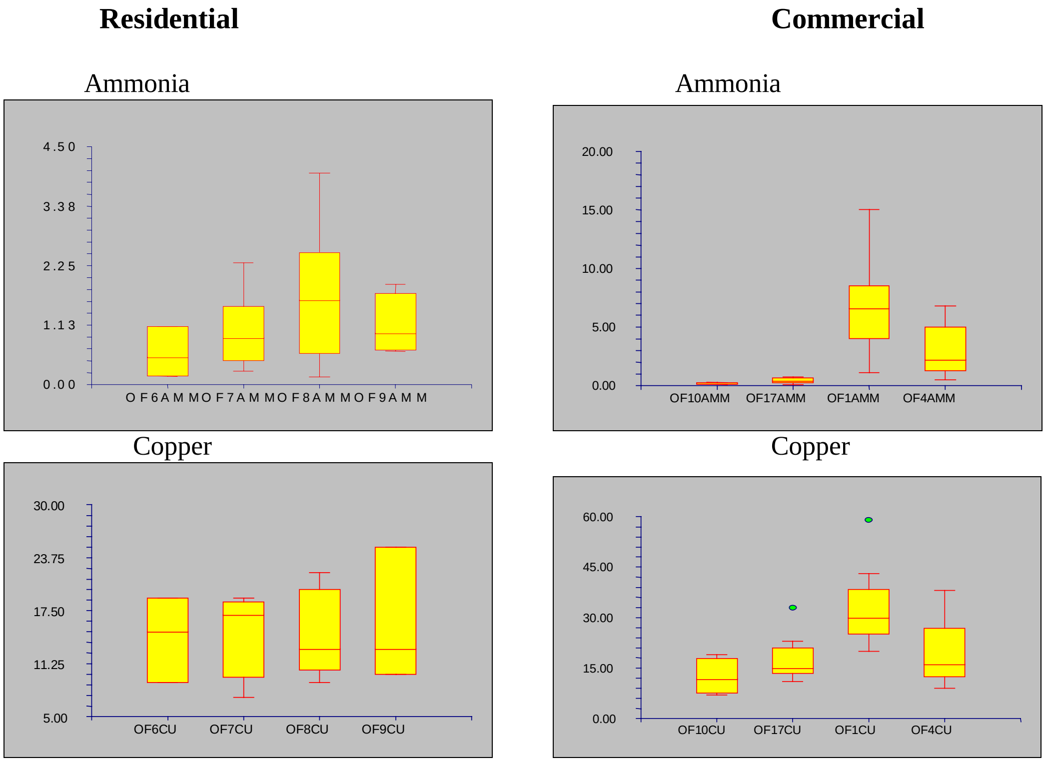

Figure 1. Sample Box Plots of Residential and Commercial/Industrial CSO Sites for Ammonia and Copper

The city monitors overflow volume and frequency at all CSO sites, in addition to precipitation. These data provide a measure of success of CSO reduction projects. Highly accurate real-time flow data is collected using permanently installed ultrasonic flowmeters and rainfall data is collected using electronic tipping bucking event-driven rain gauges at three locations throughout the city.

Substantial reduction in CSO volume and frequency has been achieved due to both construction projects in the right-of-way and private property. Construction projects in the right-of-way include separating storm sewers from sanitary sewers and stormwater storage and treatment facilities. Removal of stormwater from the sanitary sewer system on private property is addressed by the Cooperative Approach to CSO Reduction Program. It features free technical site assessments by city staff, pay compensation for disconnecting storm flows, and city-funded construction of work performed in the right-of-way. The public education/outreach portion of the program provides a website (http://www.cityofbremerton.com, 2000), brochures, and a video.

Figure 2 shows the success in reduction of sewer overflow discharges from 1997 to 2000. Precipitation for the year 2000 was an average of 34.3”, 22.5” lower than the average rainfall of the last five record-breaking years of 56.62”. Although a dry year, flow volume for 2000 using a precipitation-adjusted mean baseline value was reduced by 96%. Nine of 15 overflow sites met the state-mandated requirement of one untreated discharge annually.

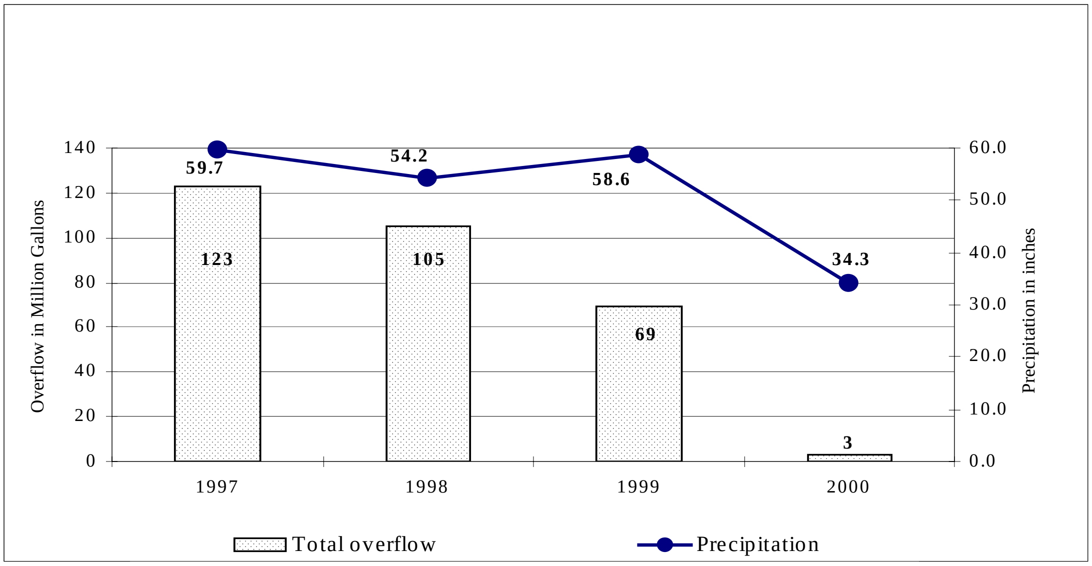

Figure 2. Bremerton annual overflows versus rainfall 1997-2000.

CSO water quality data has provided benefits to both the city and regional efforts to better understand the role of sewer discharges as related to overall water quality. The City of Seattle incorporated Bremerton's data in their "Report of Findings: CSO Characterization Project" (EVS Environmental Consultants, Inc., 2000). Data of combined sewer discharges from the Cities of Vancouver (British Columbia), Bremerton and King County showed pollutant levels were dependent upon the land use of the drainage basin.

The United States Navy is performing a watershed assessment for Sinclair and Dyes Inlets. An extension of this effort is the Shellfish Working Group. Members include Washington State Department of Health Shellfish Programs, US Navy, Suquamish Tribe, City of Bremerton and Kitsap County. The group is working to apply an HSPF-CH3D model to predict the impact of CSO discharges on shellfish beds in Dyes Inlet (Johnston, 2001). CSO water quality and flow volumes will be invaluable in the model.

Monitoring for Inappropriate Connections to the Stormwater System

The City of Bremerton is scheduled to receive an NPDES permit for stormwater in 2002. Monitoring for illicit connections will be a requirement. The city began an annual illicit connection survey program in 1996 well ahead of the requirement (Fohn and Berthiaume 1996).

The city has 14 storm drainage basins covering over 6,000 acres. The system is predominantly pipes with some swales. Sixty-four identified discharge locations and 14 outfalls are visually inspected for flow during the driest time of the year, usually August. If flow is found, samples are collected for analysis of sewage pollutants. The results determine if the flow is of a wastewater source. If so, then action items are forwarded to the Engineering and Operations Divisions for correction.

Selected water quality data from surveys for six discharge locations in five basins are shown in Table 2. Fecal coliforms, ammonia and surfactants were the most reliable indicator of poor water quality. One of the six locations was verified to be an inappropriate connection, 202-1 in the East Park Basin. This site was verified by smoke test when video inspection was inconclusive. That site demonstrated intermittent flows characteristic of a connection in an otherwise dry stormwater system typical of late summer. The other locations have flows during the late summer and were subject to poor water quality possibly due to some other source or an illicit connection that could not be discovered. Efforts are underway to determine the pollutant sources.

Table 2. Finding inappropriate connections in Bremerton. Yellow results indicate pollutants entering the storm drainage system. Selected sample results for inappropriate connection survey 1996-2000.

	Date	Flow L/min	Surfactants mg/L	Cl2 mg/L	NH3-N mg/L	CaCO3 mg/L	Cu mg/L	Fecals cfu/100ml
Pine Road Basin								
208-1	8/13/96	40	0.10	0.04	0.16	70	0.01	294
	9/2/97	40	0.00	0.07	0.16	64	0.01	104
	8/3/98	40	0.00	0.06	0.19	58	0.02	1760
	8/9/99	40-60	0.00	0.00	<0.05	48	0.02	4
	7/13/00	40	0.17	0.09	<0.01		<0.01	22
East Park Basin								
202-1	8/12/99	Intermittent	0.25	0.01	<0.05	48	0.01	332
	9/2/99	Intermittent	2.00	0.02	3.80	40	0.03	1650
	7/18/00	Intermittent	ND	ND	ND	ND	ND	>10000
Warren Avenue Basin								
103-4	8/26/96	1	0.25	0.01	1.38	410	0.22	35
	8/26/96	5	0.25	ND	0.97	518	0.09	255
	9/3/97	3	2.00	0.02	6.30	ND	1.55	3240
	11/3/97	ND	ND	ND	ND	ND	ND	3060
	8/12/99	1	0.00	0.08	0.35	344	0.02	26
Anderson Cove Basin								
112-1	8/26/96	40	0.50	ND	0.43	72	0.02	555
	9/3/97	2	0.25	0.02	1.23	152	0.00	210
	8/3/98	Could not access last manhole						
Phinney Bay Basin								
114-1	8/27/96	2	ND	0.02	0.14	80	0.02	75
	9/3/97	4	0.00	0.00	0.13	70	0.01	192
	8/4/98	4	0.00	0.03	0.12	78	0.06	360
	9/8/99	4	0.00	0.03	0.01	72	<0.005	32
	7/20/00	4	0.00	0.07	<0.01	88	<0.005	142
114-2	8/27/96	2	0.20	0.00	0.51	82	0.00	390
	9/3/97	4	0.25	ND	1.61	70	0.00	1720
	8/4/98	5	0.00	0.02	0.17	68	0.29	880
	9/8/99	4	0.00	0.01	0.01	72	<0.005	228
	7/20/00	4	0.00	0.07	0.03	76	<0.005	324

Additional benefits of surveys of the storm system include updating existing maps and locating potentially harmful stormwater configuration which were corrected.

Management of the Union River Reservoir

The City of Bremerton supplies drinking water to 55,000 people and the Puget Sound Naval Shipyard. Sixty-five percent of the 8 million gallons average day demand comes from the Union River Reservoir and the remainder is supplemented from 12 groundwater wells. The water quality and operation of the Union River drinking water source is so exceptional, it is one of the few surface water sources in the United States allowed to remain unfiltered.

The Union River Reservoir is located behind Casad Dam. The dam is located upstream of McKenna Falls, a natural barrier to salmon migration. The summer chum stock of the Union River is listed as an endangered species. The Union River is the only viable summer chum population in Hood Canal (Point No

Point Treaty Council 1999). The city fulfills required instream flows from the reservoir downstream to the Union River.

The reservoir stratifies in summer with a warmer layer of water on top of a colder layer as shown in Figure 3. The city has the ability to draw water from three different depths. To determine if the city would be providing water with a temperature higher than the current water quality standard of 16C, water temperature data loggers at sites are installed below the dam from May to October. Additionally, the Washington State Department of Ecology is proposing changing the temperature criteria. The temperature probes collect data at 15-minute intervals and are deployed using the Timber-Fish-Wildlife Monitoring Methods (Earle 1998).

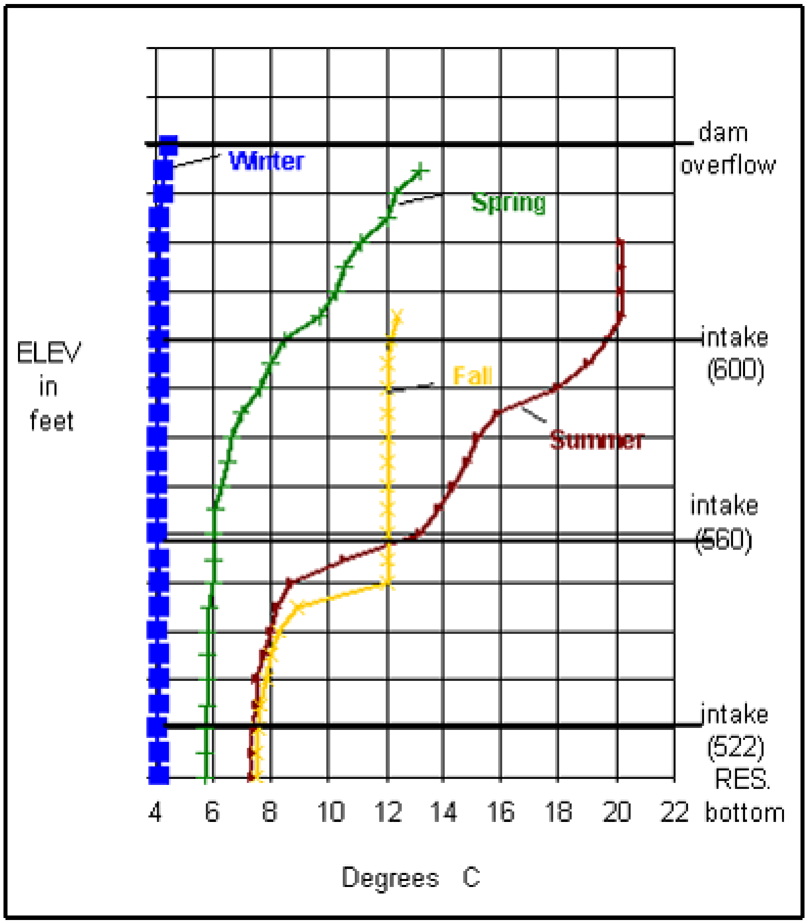

Figure 3. Temperature Stratification of the Union River Reservoir.

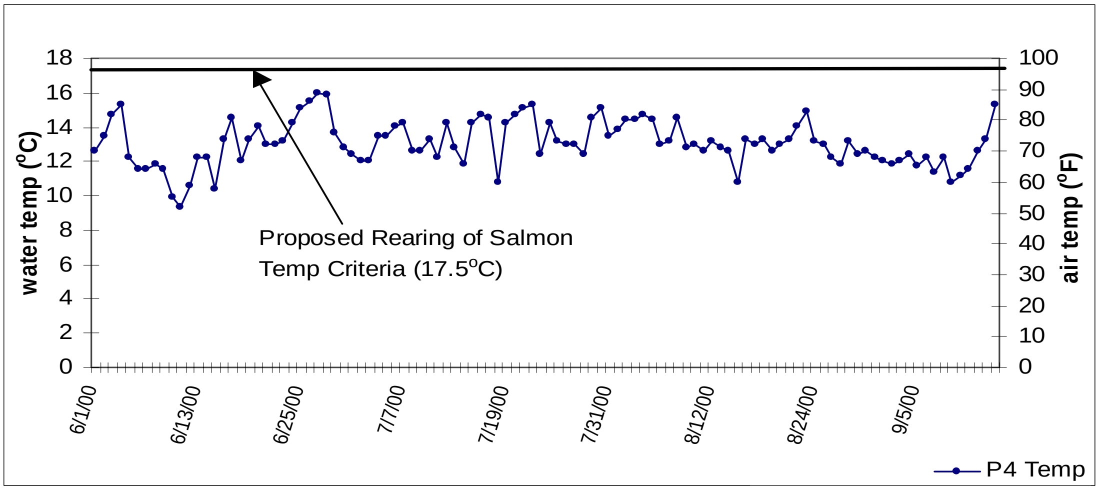

Figure 4. Union River Daily High Water Temperature June 1 through September 14, 2000.

As shown in Figure 4, the daily temperature of the downstream flows provided to the Union River from the City of Bremerton Union River Reservoir does not exceed current or proposed stream temperature water quality standards.

Evaluation of Stream Health in Watersheds with Utility Operations

The City of Bremerton, Public Works and Utilities, Forestry Division performs operations on approximately 8,000 acres of forestland in the Gorst and Union River watersheds. Timber management functions include same age harvest, cable thinning, conventional thinning, road building, and culvert building and replacement. Funds from timber sales are returned to the Water Utility for Capital Improvement Projects needed to maintain high water quality and meet state and federal regulations. Additionally, biosolids from the City of Bremerton Wastewater Treatment Plant are applied to forest lands in the Gorst watershed as permitted by the Bremerton-Kitsap County Health District and the Washington State Department of Ecology.

The city performs environmental monitoring to assess impacts to the forest lands. Biosolids-applied forest lands have been monitored for metals and nutrients in soils and groundwater; and nutrients in streams and root-zone water (Fohn 1999). More than 10 years of data have been collected. The city plans to perform an analysis of these data for long-term trend implications.

In 1997 the city performed selective timber harvest and road building near the West Branch of the Union River, a seasonal drinking water source for the city. The city performed reference point survey prior to activity and the two years following activity. Reference point survey determines the depth and width of the stream bed at specific intervals. In a disturbed watershed the stream bankful depth and width will show changes such as becoming more shallow and wide. The canopy closure was determined at each survey point to document changes in shading of the stream. The city became certified in the Timber-Fish-Wildlife Methods (TFW Monitoring 1998). Figure 4 shows little change in the bankful width, bankful depth, width to depth ration, and the canopy closure before and after activities in the watershed.

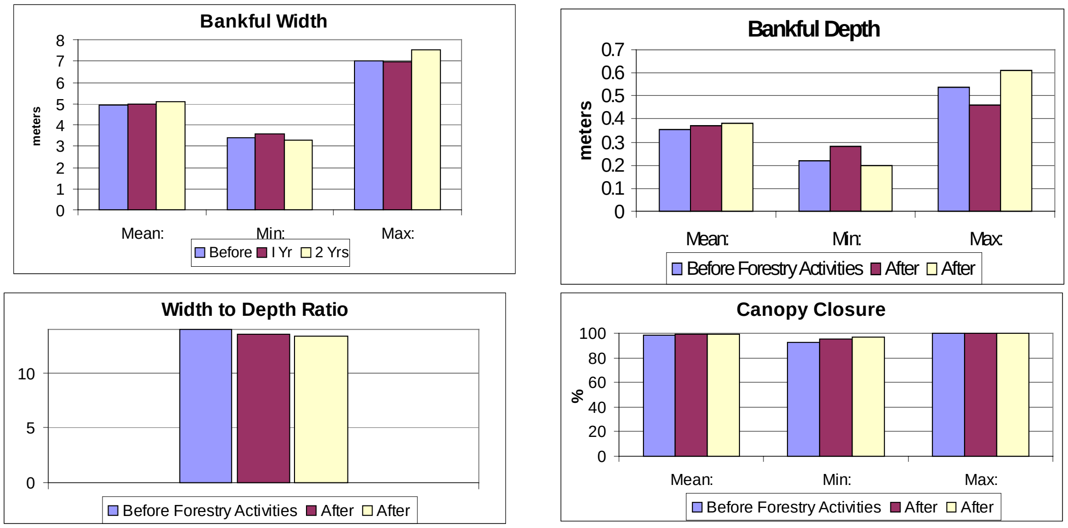

Figure 5. **Reference Point Survey of West Branch Union River.**

Conclusions

The City of Bremerton performs environmental monitoring to meet regulatory requirements, predict compliance with proposed regulations, and determine the impacts of municipal operations on water resources. The city contributes data for local watershed studies including: the Navy ENNVEST Program to model Dyes and Sinclair Inlet watersheds, Shellfish Working Group, and watershed planning for WRIA 15.

Acknowledgements

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